XII.—*On a new Species of* Idotea.

By Charles Chilton, M.A. (New Zealand).

[Plate V. A. figs. 1–3.]

In the 'New Zealand Journal of Science,' vol. i. p. 332, Mr. G. M. Thomson gives a complete list of the New-Zealand species of Idoteidæ, altering some of the names by which the species were previously known, in accordance with Mr. Miers's elaborate revision of the family*. Of the seven species mentioned in this note I have only seen two—*Idotea ungulata*, Pallas (previously known as *I. affinis*), and *Idotea elongata*, White. Both of these are fairly common in Lyttelton Harbour, and I have also specimens of *Idotea elongata* from Akaroa, collected by Mr. R. M. Laing. My specimens of *Idotea ungulata* were all taken on green seaweed, which they closely resemble in colour; while *Idotea elongata* I have found only on brown seaweed, and it is itself of the same colour. In a note published in the 'New Zealand Journal of Science,' vol. i. p. 517, I recorded the fact that in the mature female of *Idotea elongata* the thorax with the brood-pouch is expanded and attains its greatest breadth in the third segment, which is twice as broad as long; I find, however, that this had been previously observed by Mr. Miers †.

I am now able to add to the list another species of *Idotea*, which appears to be new. It comes under Mr. Miers's section ii. *a** [see *l. c.* p. 25], but is quite distinct from the species he mentions under that section. It was taken at Sumner, Canterbury, N. Z., on the under surface of a boulder, which was at the time not covered with water, since it was low tide. I have only the one specimen. I append a detailed description.

Idotea festiva, sp. nov. (Pl. V. A. fig. 1.)

Body not very convex, oblong oval, length about two and a half times the greatest breadth. Head transverse, produced upwards and forwards into a rounded prominence divided into two lobes by a median depression, which is continued nearly to the posterior margin; remainder of the head variously sculptured and with two raised ridges towards the lateral borders. First five segments of the thorax of nearly equal length, sixth and seventh shorter, seventh shorter than the

* 'Journal of the Linnean Society,' vol. xvi. p. 1.
† *Loc. cit.* p. 55.

sixth. First segment produced into rounded antero-lateral lobes, which reach to the eyes. Two raised ridges, one near each lateral border, run throughout the whole length of the thorax, and extend nearly to the end of the postabdomen. There is also a less perfect median ridge formed by the posterior portion of each segment being raised into two short converging ridges, like the letter V; this ridge is well marked in the postabdomen and extends right to the end. Between the lateral ridges and the median ridge, but nearer to the former, are various sculptured markings. Postabdomen about as long as the five preceding segments of the thorax, composed of three distinct segments, the first two short, the third with the lateral sutures of another segment. Postabdomen gradually narrowing until about one third of its length from the end, when it suddenly contracts and converges with slightly sinuous margins to the extremity, which is subacute. Eyes small, situated on the lateral margin of the head at the postero-lateral angle. Antennæ reaching nearly to the end of the third segment of the peduncle of the antennule; penultimate segment expanding distally, terminal segment very small. Antennules as long as the head and first two segments of thorax; last segment of peduncle longer than the preceding, but slightly shorter than the flagellum, which is composed (in my single specimen) of seven joints, of which the first is considerably longer than any of the succeeding. Epimera of only the last three segments of thorax visible in dorsal view; in side view they are all rectangular, those of second and third segments not reaching to the anterior end of the epimeron of succeeding segment. Opercular plates subtriangular, with slightly raised border on inner margin; terminal plates very small, triangular, ending acutely. Legs short, not visible in dorsal view. Colour greyish.

Length 10 millim.; breadth (about) 4 millim.

Hab. Sumner, Canterbury, New Zealand.

A single specimen, taken on the under surface of a boulder exposed at low tide.

EXPLANATION OF PLATE V. A. figs. 1–3.

Fig. 1. *Idotea festiva*, dorsal view, × 10.
Fig. 2. The same, side view, × 10.
Fig. 3. The same, opercular plates, × (about) 13.

XIII.—*On the Reproduction and Development of* Rotifer vulgaris. By Dr. Otto Zacharias *.

[Plate V. B.]

Rotifer vulgaris, as its name implies, is one of the commonest of the Rotatoria. Spallanzani observed it and made interesting experiments upon its faculty of reviving after complete desiccation. It is to be met with abundantly throughout the whole year in ponds, ditches, and pools. But notwithstanding the constant opportunity presented for its examination, *Rotifer vulgaris* has not yet been accurately investigated with regard to either its anatomical structure or its developmental history.

In the following pages I give a detailed report of the results of an investigation of this Rotifer commenced in February and continued until the middle of July in the present year (1884).

I. *Historical.*

Thirty years ago it was regarded as unsettled whether the Rotatoria are of separate sexes or hermaphrodites. The standpoint of investigation at that time will be best characterized by a passage from Siebold's 'Comparative Anatomy,' which I will here cite verbatim. It runs as follows:—"As the Rotatoria are provided with such distinct *female* sexual organs, one might also justly infer the existence of *male* generative organs in these animals; but notwithstanding the most careful endeavours, no satisfactory result as to the true nature of their male sexual apparatus has hitherto been attained, so that it is still doubtful whether the Rotatoria are hermaphrodites or possess separate sexes" †.

While these words were being published and read in Germany, the English naturalist, Brightwell ‡, discovered the small misshapen male of a Rotifer allied to Ehrenberg's genus *Notommata*, previously altogether overlooked. This was an epoch-making discovery, the importance of which was immediately recognized by Dalrymple and further developed by him in a detailed special investigation. The last-named naturalist furnished the proof that the male of *Notom-*

* Translated by W. S. Dallas, F.L.S., from the 'Zeitschrift für wissenschaftliche Zoologie,' Band xli. pp. 226–251.

† Vergl. Anat. p. 184 (1848).

‡ Ann. & Mag. Nat. Hist. ser. 2, vol. ii. p. 153 (1848).

mata anglica possessed neither jaws, nor pharynx, nor stomach, but lived solely for amatory purposes *. Brightwell and Dalrymple are entitled to perfectly equal shares in the merit of this most important discovery, but hitherto only the latter has been mentioned by name in the text-books.

Some years afterwards (1854) Prof. Franz Leydig found himself in a position to demonstrate separate sexuality in a second example, a Rotifer newly discovered by him (*Notommata Sieboldii*). The female of this new species has a great similarity to that of *Notommata anglica*, but the male is very differently constructed. It is especially by the presence of four lappet-like arms (one pair situated at the neck, the other issuing from the middle of the body) that this male is distinguishable from that of the English Rotifer. In this case also it was proved that the male of *Notommata Sieboldii* possessed neither pharynx, jaws, nor stomach.

By these fortunate and important discoveries the notion was gradually established that separation of the sexes occurs throughout the Rotatoria; and Leydig expressed his (certainly not merely individual) opinion upon this point in the following terms. He says:—"In their structure the Rotatoria manifest too great a harmony for us not to draw the conclusion from the sexual difference of *Notommata anglica* and *Notommata Sieboldii* that the other genera also have the sexes separated upon two individuals" †.

The acumen and circumspection of Leydig soon succeeded in diagnosing other male forms from the descriptions and figures given by other naturalists. Thus Leydig established as clearly as possible that Ehrenberg's genus *Enteroplea hydatina* was erroneously described as a distinct genus, its representative really being only the male of *Hydatina senta*. Leydig also thought, and correctly, that *Notommata granularis* would prove to be the male of *N. brachionus*. This supposition, as is well known, was verified by F. Weisse (St. Petersburg).

By the Breslau naturalist Prof. Ferdinand Cohn, who has occupied himself in the most thorough-going manner with the organization of the Rotatoria, the reproduction of these animals was in 1854 made the subject of a special publication ‡. This is especially valuable, because Cohn was so fortunate as to be able to confirm Leydig's inferences by experiment, and thus the incontrovertible proof was furnished

* Phil. Trans. ser. 2, vol. iii. (1849).

† "Ueber Bau und die systematische Stellung der Räderthiere," Zeitschr. f. wiss. Zool. vi. 1855, p. 98.

‡ Zeitschr. f. wiss. Zool. vii. (1855), pp. 431–436.

that *Enteroplea hydatina* was the male of *Hydatina senta* and *Notommata granularis* that of *N. brachionus*.

Three years later (1858) F. Cohn communicated the results of his further investigations in an interesting memoir which appeared under the title of "Remarks on the Rotatoria," in the ninth volume of this 'Zeitschrift.' In the concluding pages of this publication Cohn expresses the opinion that in the Rotatoria a peculiar form of alternation of generations occurs, thus constituted:—"the fecundated females alone deposit hard-shelled ova, which pass through the winter, while the unfertilized summer eggs are developed, from which proceed directly either females again or, at certain seasons, males also."

Valuable information as to the anomalous structure of many Rotatoria was given in a memoir by Metschnikoff which was published in 1866 *. It treats of *Apsilus lentiformis*, the most remarkable peculiarity of which consists in the absence of any vibratile apparatus. This Rotifer also has separate sexes. This fact was first ascertained by Prof. R. Leuckart. Here also it was proved that the male is destitute of all traces of the digestive organs, while, on the other hand, the aquiferous system shows a considerable development.

It was ascertained by W. Salensky, who observed the embryonic evolution in *Brachionus urceolaris* (1871), that in this Rotifer the development of the two sexes takes place quite concordantly in the first stages. Only at a later period does the intestinal canal, which originally occurs as an invagination on the ventral surface in both males and females, undergo in the former a retrogressive metamorphosis and become aborted †.

Quite recently (1883) a memoir by Karl Eckstein ‡ upon the Rotatoria of the neighbourhood of Giessen has been published, containing numerous valuable observations. With regard to *Rotifer vulgaris*, however, even this memoir gives us very little information, and in the following statements I find myself thrown principally upon my own observations.

II. *The Material*

for my observations I obtained in two ponds situated directly in front of my house at Curmersdorf. Subsequently I obtained it from the "Froschgraben" which stretches between the town of Hirschberg and the village of Grunau, a locality which, after Von Flotow's and F. Cohn's investigations upon

* Zeitschr. f. wiss. Zool. xvi. (1866), pp. 346–356.
† *Ibid.* xxii. (1872), pp. 455–466.
‡ *Ibid.* xxxix. (1880), pp. 343–443.

Hæmatococcus pluvialis and *Stephanosphæra pluvialis*, must certainly be well known to a wide circle of naturalists. The last-mentioned interesting Volvocinean occurs in great abundance in the stagnant water of this ditch.

At almost all seasons the Froschgraben possesses an abundant fauna. Besides numerous species of *Chironomus*-larvæ, Cyclopidæ, Entomostraca (*Lynceus*), Nematoda, and Infusoria, three different species of Rotatoria are to be found here, viz.:—

1. *Philodina roseola.*
2. *Eosphora najas.*
3. *Rotifer vulgaris*:
   (*a*) in a very large form (0·75 millim.), with reddish cuticle;
   (*β*) in a smaller form (0·50 millim.), with perfectly colourless cuticle.

As I needed a great number of specimens I have experimented with the smaller *Rotifer*; the other two species did not occur in sufficient abundance, and I employed them chiefly only to obtain a more accurate notion of the characters of the Rotatorian organism. I found the large *Rotifer* cited under "3 *a*" specially adapted for this purpose; from its shagreened cuticle it might be characterized as *Rotifer granularis*.

III. *The Anatomy of* Rotifer vulgaris.

The external boundary of the bilaterally symmetrical body of our *Rotifer* is formed by a finely longitudinally striated, transparent cuticle, the interior, softer portion of which (hypodermis) consists of a homogeneous ground-mass with scattered granules. Leydig, who was the first to notice the existence of this second layer, describes it as the granular layer. The telescopically extensible foot (like the cervical process or proboscis) is to be regarded as merely an extension of the cuticle, not as an organ articulated to the latter. Division into segments, in the sense in which it occurs in the Arthropoda, is no more to be discovered in *Rotifer* than in the other Rotatoria. By this, however, it is by no means intended to deny that a sort of superficial segmentation divides the body in the Rotatoria into several segments placed one behind the other; this is undeniably the case, but no metamerous arrangement of the internal organs corresponds to these apparent segments. Bütschli therefore has rightly come to the conclusion that the jointing of the Rotatoria is typically different from the segmentation of the Annelida*.

* Zeitschr. f. wiss. Zool. xxvi. (1876).

In *Rotifer*, as in the other Philodineæ, the buccal aperture is *ventral*, and the anal opening *dorsal*.

The reception of nourishment is effected by means of the so-called "rotatory organ," from which the whole group of animals has obtained its name. In *Rotifer* this organ consists of two lobes, situated before the mouth and directed outwards like wings, which bear a strongly vibratile circlet of cilia, and have the office of whirling in nutritive material. The optical impression received by the observer of the incessant ciliary movement is that of two rapidly revolving wheels, and hence the name of "Wheel-animalcules" applied to them. This organ, which can be protruded and retracted at pleasure by the Rotifers, forms the true cephalic extremity; and the vermiform anterior third of the body, which bears the carmine-red eye-spots, may justly be regarded as a proboscidiform elongation. When the rotatory organ is retracted, a system of radiately arranged folds indicates the place where it is hidden in the body-cavity. When it is to be protruded, the animal shortens its anterior extremity about one half, and throws it quite back upon the neck, much as shown in fig. 2. During this sudden backward movement the border of the rotatory organ issues, already vibrating, and the motor muscles of the latter protrude the two "præoral lobes" completely. The play of the cilia begins immediately, and numerous swarm-spores of Algæ, Diatomaceæ, Infusoria, &c. are carried down into the *œsophagus*, which is also lined with cilia.

This latter leads into the so-called pharynx [mastax], which contains the two denticulated jaw-plates, and possesses a strong apparatus of muscles. When the rotatory organ is unfolded these plates are in constant movement and ready to crush whatever comes within their reach. By the older observers (Leeuwenhoek, Joblot, Fontane) the masticating apparatus of the Rotifera was erroneously regarded as a heart. If we examine a specimen of *Rotifer*, lying with the ventral surface upwards, under a microscope of good definition with a power of 750 diameters, we see the lower surface of the pharynx, which is turned towards us, furnished with three gland-like appendages. The third and largest one pushes itself, like a wedge, between the two smaller ones, which converge towards one another, and thus is produced a glandular complex which occupies the whole lower surface of the pharynx. Eckstein (*l. c.* p. 445) thinks that in *Rotifer* and *Philodina* no separate lobes are to be distinguished in the glandular mass. I can explain this statement, which differs completely from the results of my own observations, only by supposing that the Giessen observer has examined the pharynx of a *Rotifer* only from the dorsal side. In this case the glandular mass protruding on each side certainly appears *un*lobed; but it is in reality not so, as the application of the microscope to the ventral surface of the animal proves. The three glandular lobes then at once catch the eye. As regards the minute structure of these glands (which may best be distinguished as *stomach-glands*), their contents consist of a pale glandular mass containing clear nuclei (with nucleoli). There can hardly be any doubt that these organs are destined to pour into the stomach a secretion subservient to digestion. As is well known, a similar provision occurs also on the pharynx of many insect-larvæ, especially in the larvæ of *Chironomus*, in which a whole circlet of such stomach-glands is always to be met with.

In the region where the œsophagus opens into the pharynx, but upon the ventral side, there are always two large cells (furnished with a nucleus), which are placed close together and apparently partially amalgamated. Frequently, instead of one, we see *two* fine round nuclei in each of these two cells.

From the pharynx the food, crushed and mixed with the glandular secretion, passes into the *chyle-intestine* (stomach), which, in the Rotifera that I have examined, possesses a distinctly perceptible intima. This is very probably to be regarded as a direct continuation of the chitinous lining of the pharynx. It also passes into the intestine and is there particularly strongly developed. This intima is surrounded by a finely granular mass, which again is enclosed by a delicate-walled tube. This mass appears to be the seat of an *absorbent* faculty, for, according to the nature of the food taken into the stomach, it immediately acquires a greenish, brownish, or reddish colour. If the animals are left to starve the granular mass gradually becomes quite decolorized, and acquires a shining grey appearance. From its function it is evidently to be compared with the epithelial cell-layer of the middle intestine of many insect-larvæ (e. g. *Chironomus*). As in these, so in *Rotifer*, the source of fat-globules is to be recognized in this absorbent layer. With abundance of nourishment extraordinarily large oil-drops make their appearance in the interior of the intestine of *Rotifer*.

The intestine, as already mentioned, possesses a very thick wall, and is generally tightly packed with excrement. It opens outwards, together with the so-called "*contractile vesicle*," into the dorsally-placed cloaca.

This vesicle, on which a considerable muscular coat is recognizable, morphologically represents only a dilated part, corresponding to the point of union, of the two *excretory* *vessels* ("respiratory canals"), which run on both sides in the interior of the body-cavity of *Rotifer* into the vicinity of the rotatory organ. These canals have throughout a lumen of equal width and a tolerably strong wall; upon them are seated at various parts the so-called tremulous organs or cilio-faculæ, about the structure of which there is still much dispute. I will here briefly state what I have been able to see in them.

In *Rotifer*, in which I counted five such organs upon each side, I have ascertained, by the employment of an excellent homogeneous immersion-lens from the workshop of E. Leitz, in Wetzlar (focus $\frac{1}{16}$ inch), with a moderate eyepiece, that each tremulous organ has the form of a cylindrical beaker, seated by its tapering extremity upon the excretory vessel. The beaker is open above, and the broad cilium inserted at its bottom projects a little beyond the aperture. I know very well that my description is imperfect, and that it differs from the representations given by other authors; but every one can say with a good conscience only what he *believes* he has observed. We are here on the limit of microscopic vision, and the probability of error is very great. I see, however, that Metschnikoff gives a similar description of the tremulous organ in *Apsilus lentiformis*, saying with regard to that Rotifer, "On each side there are two funnels opening into the body-cavity. In the base of each funnel is seated a long lobe vibrating in an outward direction" *. From my observations I must perfectly agree with the Russian naturalist, although so distinguished an observer of the Rotifera as Leydig states that in the tremulous organs observed by him the direction of the oscillation is *inwards*. Even under a power of 1500 diameters (Leitz's homogeneous immersion of $\frac{1}{16}$ inch and ocular no. 3) the condition of things appeared to me not otherwise than as above described. I saw that the oscillation of the cilia was so violent that the beakers surrounding them were kept in constant tremulous movement.

After these observations I determined to bring the tremulous organs of a female of *Brachionus urceolaris* into comparison. A fine large specimen was soon found, and this I examined under exactly the same power as my *Rotiferi*. The result obtained, however, was not of such a kind that I could employ it in support of my observations on the tremulous organs of *Rotifer vulgaris*. I will here merely describe what I observed, without troubling myself as to how it is to be brought into accordance with the previous observations upon *Rotifer*. I took the greatest trouble to discover a contour

* Zeitschr. f. wiss. Zool. xvi. p. 349 (1866).

which *might* be construed as indicating an aperture; but in this endeavour I did not succeed. It even appeared that the direction of oscillation was *inwards*, and that the cilium, which beat much more violently than in *Rotifer*, was attached to the upper closed end of the organ.

I repeated my observations upon this point a few days afterwards, but came again to the same result.

Now I find from Eckstein's memoir that this naturalist has made observations upon the tremulous organs of *Rotifer vulgaris* which differ considerably from mine, and rather agree with what I believe I have seen in *Brachionus*. I say expressly that for my own part I indeed entertain the conviction that I *could* see nothing else in the material at my disposal; but this does not exclude the possibility that other observers may have had the advantage of more favourable objects, and perhaps made more numerous observations than myself.

According to Eckstein the tremulous organs of *Rotifer vulgaris* are of a clavate form and attached by the thinner end to the lateral canals. At the upper end they are closed by a hemispherical lid, to the middle of which the long cilium is attached. Beneath this lid Eckstein thought he detected an oval aperture, which, however, does not extend to the free extremity of the cilium. In his opinion, which is identical with that of Leydig, the waste fluids of the body are carried from the body-cavity into the excretory ducts by the vibrating cilium, passing from them into the contractile vesicle, and thence outwards.

I leave this observation to stand on the same footing that I claim for my own. Eckstein certainly only states what he has seen. In the presence of such diverse observations, however, one may inquire into the cause of the diversity, and this, in my judgment, is to be found in the influence which the quicker or slower motion of the oscillatory cilium exerts upon our visual organs. In *Rotifer*, in which the cilium oscillates more slowly, I had the impression that the beaker-like organ was open at the top. But in the tremulous organ of *Brachionus*, in which the cilium shows a strong flickering motion, and oscillates in short undulations, the resulting motion from this, in combination with the recognition of the *convergent* lateral contours of the organ, is that the latter must be closed above. This conclusion we arrive at quite against our will, because a briefly undulating cilium, projecting somewhat above the margin, simulates the optical section of a cap-like operculum, which really does not exist. That K. Eckstein has recognized a "hemispherical operculum" also in *Rotifer* may perhaps be due to the individual constitution of his visual organ or to the circumstance that his specimens of *Rotifer* were furnished with more rapidly vibrating cilia (*i. e.* fresher) than mine.

It is waste of time to dispute about this. All observations in which we must approach the limit of microscopic vision are precarious. Consider only the question as to the general constitution of the striated muscular fibre, as to which the observations of investigators are often diametrically opposed. Wherever the diffraction phenomena of light come into play microscopic anatomy must put a bridle upon its desire of knowledge.

I proceed now with the exposition of the anatomical characters of the body of *Rotifer*. On each side of the chyle-intestine, about the hinder third of the body, are situated the fusiform ovaries. One of them is usually considerably larger than the other; but each of them is enveloped by a thin transparent membrane, which is drawn out at each end of the organ into a solid cord. The posterior and thicker of these cords passes into the foot and is attached in the vicinity of the contractile vesicle; the other is longer and more delicate, so that its point of attachment in the anterior part of the body can with difficulty be determined. It is not to be denied that this mode of attachment of the ovaries has a striking similarity to those which occur in the still undeveloped ovaries of the larvæ of *Chironomus plumosus*, *Corethra*, &c. As is well known the above-mentioned Dipterous larvæ, shortly before their escape from the egg (frequently also even earlier), already possess, in the last segment but three, on each side a distinctly recognizable, fusiform sexual rudiment, which, indeed, is frequently concealed by the adipose body, but is never wanting in the portion of the body indicated. In *Rotifer* and the other Rotatoria each ovary consists of a finely granular colourless substance, in which are imbedded large dark nuclei, surrounded by lighter spaces. Leydig has interpreted the nuclei as germinal spots and the light zones around them as germinal vesicles. In the smaller ovaries I count five or six, in the larger ones from twelve to fifteen such structures. Frequently the ovaries seem nearly to disappear; at least I have observed that in many examples of *Rotifer* they are scarcely a fourth of their original size.

In the description of the body-cavity of *Rotifer* it must also be mentioned that it is seldom quite free from embryos. Usually three are contained in it, one of which is generally pretty far developed, while the other two are only in course of formation. During the movements of the parent-animal the progeny are driven to and fro in the most reckless fashion, stuck up on their heads, pushed on one side, and in general their existence is so completely ignored that it is wonderful how, under such circumstances, the young Rotifers manage to get developed. But in spite of the observer's wonder this takes place, according to the temperature of the water, in from five to eight days after the separation of the ovum from the ovarium. The actual birth I have never been able to observe, and it is to me quite a mystery through what portal the young animal quits the body-cavity of the mother.

We have still to glance at the anterior portion of the body of *Rotifer*, which bears the two carmine-red eye-spots, each furnished with a crystalline body. When examined from the dorsal surface this section shows, in the first place, the triangular *ganglion*, placed immediately in front of the masticatory apparatus. In *Philodina roseola* the eye-spots are situated immediately over this triangle (in the nape), and it looks exactly as if the animal carried about with it upon its back the drawing of a fox's head with the snout in front. The resemblance is striking, and by no means depends upon a subjective notion. In *Rotifer* the anterior angle of the triangle emits two hardly visible branches towards the two eye-spots. Besides these there seems to me to be a union of the same angle with the retractile organ which exists at the extreme anterior end of the body, and bears a circlet of short cilia, together with two long tactile setæ. The so-called *cervical lobe* (erroneously named "respiratory tube") is also united with the cerebral ganglion by a commissure. Here, no doubt, we have to do with a sense-organ, as is proved by the fact that the animal (before passing from the contracted to the extended state) protrudes this lobe to feel about, and quickly retracts it again if a *Paramæcium* or a *Daphnia* comes in contact with it in swimming by. At its superior extremity the organ bears a tuft of tactile setæ. In fig. 3 I give a superficial and lateral view of the anterior extremity of the body in *Rotifer*, from which the reader may easily understand the conditions which occur.

When the rotatory organ is retracted it appears in the dorsal view in the form of two semicircular plates, of which the middle part refracts the light less strongly than the margin, which appears somewhat inflated. On each side there is in anatomical connection with the posteriorly directed horn of these plates, a lobiform mass of substance, as to the interpretation of which I am not quite clear. When the rotatory organ is protruded the two lobes in question move somewhat further forward, so that they appear to be half taken into that organ. Have we to do here with salivary glands (besides the above-mentioned stomachal glands)? This I do not know.

I have still to say a few words about the *muscular system* and the "*pedal glands.*" As to the function of the latter we have only recently ascertained anything. With Ehrenberg these "clavate, turbid, elongated bodies" were problematical organs. In interpreting them he hesitated between muscles and sexual glands. We now know that they are the seat of a secretory activity, and secrete a sticky product, which serves to attach the animal to smooth surfaces. As regards the muscles, I shall content myself with stating that the masticatory apparatus and contractile vesicle possess special muscles, while elsewhere longitudinal and transverse muscles are present. The latter were regarded by Ehrenberg as blood-vessels. In *Rotifer* we observe in the region of the head a complex ramification of muscular fibres, which cannot be specially traced. There is no circulatory apparatus for the blood in any *Rotifer.* The *blood* occupies the body-cavity quite freely, and its movement is maintained by the contractions of the body. True blood-cells cannot be recognized; but at all times fine fusiform and rounded elements are suspended in the body-fluid, which very probably functionally represent blood-cells.

IV. *The Embryonic Development of* Rotifer vulgaris.

When we have a great number of specimens of *Rotifer* at command, we always find one or more of them in which the *constriction of the ovum from the ovary* may be traced. There is first produced a small swelling on the latter. On close observation this proves to be densely packed with vitelline granules, so that the gradually increasing raised portion stands out clearly by its darker and granulated appearance against the ovary, which remains clear. It now appears as if all the vitelline formative material collected together at a single point of the ovary. Something of the same kind must also have been recognized by previous observers in other species of Rotatoria. Thus Leydig describes the ovary of *Notommata centrura*, and says:—"Only one half of it has vitelline granules, among which again numerous darker spots of accumulation are to be recognized." Upon the horseshoe-shaped ovary of *Pterodina patina* the same author also remarks as follows:—"In one limb we distinguish the germinal vesicles with their germ-spots and the finely granular vitelline mass between them; the other limb displays scarcely anything but vitelline substance, the molecules of which are here larger." Similar observations were also made by Prof. Leydig upon the ovaries of *Brachionus*, *Noteus*, and *Euchlanis*, from which that naturalist thinks he may draw the conclusion that in the ovaries of the Rotatoria in question we have an approximation to those forms of ovaries in which (as in Hexapoda and Asellina) the production of the germinal vesicles and of the yelk-mass devolves upon different parts of the ovary*.

According to what I have quite definitely observed in my *Rotifer* I cannot adopt this view. It certainly *appears* as if a separate vitelligenous focus existed in such ovaries; but we soon see the germinal vesicle come into sight in the midst of the swelling and take its place outside the ovary. The swelling, which is originally sessile upon the ovary, increases gradually in size and becomes more and more sharply constricted off from its place of origin. Finally the conditions are reversed: the maturing ovum gradually attains its definitive size, and then we see the much-diminished ovary attached to the ovum, while previously the reverse was the case.

The separation by constriction is at last completed (in about three or four hours), and the ovum, in which the germinal vesicle with the germinal spot is distinctly visible, drops into the body-cavity, where it is driven to and fro in the most unceremonious manner by the contractions of the animal. The process of separation is so effected that a portion of the enveloping membrane of the ovary is separated with it and transferred to the ovum, so that the embryo in its development lies in a completely closed hyaline vesicle, which, from its origin and function, is to be regarded as a real *uterus* ("*poche de maturation*," Joliet). Under a magnifying-power of 700 diameters, with good definition, the envelope surrounding the embryo (the presence of which has often been disputed) may be recognized with the greatest distinctness.

The *segmentation* of the egg of *Rotifer* is very difficult of observation, because the animals suitable for investigation cannot at pleasure be brought to repose and prevented from creeping about. The application of a compressorium is injudicious, as the least pressure exerted upon the objects under observation causes their contraction. There is nothing for it therefore but to arm one's self with patience and to take care to keep the egg constantly in the field of vision by suitable movements of the object-slide. Very often, however, the desirable circumstance occurs that the animalcules attach themselves with the foot, unfold the rotatory organ, and remain for ten or twenty minutes in this condition. This happens, however, only when they feel quite comfortable, and the illumination is not too bright.

* Zeitschr. f. wiss. Zool. vi. (1855), pp. 37, 47, and 94.

The following is what I have been able to ascertain by the investigations of months (February to July 1884) upon the development of *Rotifer vulgaris*. After its separation from the ovary the egg shows a centrally-placed germinal vesicle with a distinct germinal spot. The development of the embryo commences by the contours of the germinal vesicle becoming indefinite, until it fades away and finally becomes quite invisible. When this has taken place the yelk-granules show a tendency to accumulate in the middle of the egg, so that a darker central mass and a lighter peripheral layer may be distinguished. In from twenty to twenty-five minutes, however, the egg-contents gradually clear again, and under suitable illumination we discover that a division of the germinal vesicle has taken place. The latter has certainly only a little diminished in size, which no doubt is to be explained by its substance having been replaced from the yelk. From the recent observations of Ludwig Will*, according to which masses of nucleus-substance issue from the germinal vesicle and become converted into yelk-substance, the reverse of this process is also conceivable. The arrangement of the products of division and the original germinal vesicle is usually such that the latter are placed in the vicinity of one pole of the egg, and the daughter vesicles in the region of the other pole.

I have never been able to observe directly in the egg of *Rotifer* the mode of segmentation; but as the daughter vesicles are always smaller than the original nucleus, it is probable that the former proceed from the latter by a process of gemmation. Something like this, as is well known, occurs also in the segmentation of the egg of *Rhodites rosæ*, in which (according to Weismann's observations) the so-called "posterior pole-nucleus" likewise increases by gemmation †.

It is worthy of note that the vitelline elements do not immediately group themselves around the progeny of the germinal vesicle, but there is rather a lapse of a certain time (several hours!) before the commencement of a blastomere-formation is to be recognized. So far as I know, this fact has previously been indicated only by Leydig, who, as long since as 1855, puts the following question with regard to it:—"Are we to conclude that the germinal vesicle in the ovarian egg has become converted directly by continual division into many nuclei . . . . . or do the winter-eggs perhaps, even at their origin in the ovary, enclose a number of nuclei (germinal

* Zool. Anzeiger, 1884, nos. 167, 168.

† Beiträge zur Kenntniss der ersten Vorgänge im Insektenei, pp. 85 *et seqq.* (1883).

vesicles), in opposition to other eggs, which always possess only one nucleus?" *

By my observations a clear light is thrown upon the occurrence of a considerable number of nuclei in the eggs of many Rotatoria, inasmuch as I have been able to ascertain that between the blastomere-formation and the increase of the original nucleus (by gemmation) there is an interval of several hours. Accidentally I once met with an egg with *four* daughter-nuclei, although no trace of the commencement of segmentation was to be observed. Generally the grouping of the vitellus into blastomeres commences when *three* nuclear buds have separated. As we shall see by this the foundation of the *epiblast* is already provided. By the formation of grooves, the progress of which is scarcely perceptible, three blastomeres are finally formed, each of which contains within it a daughter-nucleus. These are seated like a saddle upon the still unsegmented larger half of the egg, and appear then to increase at the expense of the latter (which visibly becomes smaller). The result of this increase is at the same time an envelopment of the half of the egg which has remained undivided by the products of division of the original three blastomeres—a process which leads to formation of a so-called *hood-gastrula*. The *outer* lamella of this is represented by the enveloping cell-mass, the *inner* one by the at first passive half of the egg, which, however, begins to be segmented when the envelopment has advanced so far that only a small aperture (blastopore) still remains to be closed.

When this closure has taken place the protoplasm of the blastomeres, which have in the meanwhile increased in number and diminished in size by repeated division, becomes fused together, and then is produced a tolerably dense layer, furnished with numerous nuclei, which no longer allows us to trace the fate of the great hypoblastic cell. But there can be no doubt that morphologically this must be regarded as the equivalent of an inner lamella, if we consider the details of the process of segmentation in the egg of a wheel-animalcule (*Philodina roseola*) nearly allied to *Rotifer vulgaris*.

In the Riesengebirge, and especially in the neighbourhood of Hirschberg (near the village of Grunau), we have a very large species of the above-mentioned *Philodina*, the eggs of which are quite peculiarly adapted for embryological observations. The intestinal canal of this animal is of a cinnabar-red colour, and we find the same pigment also in the vitelline granules of the egg, a circumstance which is of particular importance, as I remarked more and more as I continued my

* Zeitschr. f. wiss. Zool. vi. p. 102 (1855).

studies from day to day. I cultivated great quantities of these animals in two small aquaria filled with rain-water. Swarm-spores of Algæ served as their food. Early in the morning (at 4 or 5 o'clock) I constantly found, seated at the margin of the aquarium, colonies of the size of a pin's head, which, on microscopic examination, proved to consist of 30–40 individuals. Among them were to be seen 50–60 eggs, either freshly deposited or already in course of development, which one of course has to make use of at once. That so many observers of Rotatoria have failed (as appears from the memoirs on the subject) in obtaining eggs *just deposited* is due simply to the fact that they did not get up early enough. So far as I can judge, the deposition of eggs in *Philodina roseola* takes place only very rarely during the later hours of the morning, and not at all in the afternoon. This condition has its analogue among the lower forms of plants. To the botanist it is well known that the conjugation of many Algæ takes place only in the earliest hours of daylight.

While the mature egg of *Philodina roseola* is still in the body-cavity of its parent, the germinal vesicle always lies at that pole which is turned towards the anal aperture. I was never able to detect a germinal spot in *Philodina roseola*.

Upon the first stages of development I have to state what follows. In the deposited egg the germinal vesicle immediately disappears, and, just as in *Rotifer*, the vitelline granules accumulate around a central point, so that a peripheral layer of protoplasm, with but few granules, makes its appearance in the egg. Gradually, however, the contents of the latter become homogeneous, but only for a time, for very soon the yelk becomes clearer at two neighbouring points of the long axis of the egg, and between these is produced the first groove, by which the contents of the egg are divided into two unequal parts. In proportion as the deepening of the groove proceeds, the nuclei of the first two segments also appear with more distinct contours. That the first segmentation-nucleus is developed by gemmation from the nucleus of the egg I have several times directly observed in *Philodina roseola*. For the elucidation of this I refer to fig. 4, in which four consecutive stages of the process of gemmation in question are represented. At the commencement of the gemmation the true viscous nuclear substance within the fine envelope containing it performs amœboid movements (stage 1, fig. 4). But within a few minutes the budding daughter-nucleus distinctly appears (stage 2). Immediately after its production this divides into two or three equivalent structures (stage 3), and I have even observed a case in which the whole nucleus (including the bud) in this stage acquired the form of a rosette (fig. 4, 4), and gave origin simultaneously to five daughter-nuclei. In the formation of the other blastomeres the origin of the daughter-nuclei belonging to them from the original germinal vesicle may almost regularly be observed.

It is worthy of mention that in the egg of *Philodina roseola* the occurrence of a small *segmentation-cavity* may be definitely recognized. *I have been able to recognize this structure, not only in isolated cases, but in all the eggs of which I witnessed the first stages of development.*

After the formation of the first *smaller* segment, the segmentation advances as follows:—Two other blastomeres are produced from the larger half of the egg, take the original first divisional piece between them, and become amalgamated with this superficially.

As in *Rotifer vulgaris*, so also here, we observe that the first three blastomeres now also divide and begin to grow round the hypoblastic half of the egg. In the latter, in the meanwhile, more vitelline granules have accumulated than in the foundation of the epiblast, by which means, as we shall see, it becomes possible to keep the hypoblastic cell in view during the subsequent development. By degrees the still unsegmented very granular portion of yelk is regularly flowed round by the dividing blastomeres, and surrounded as with a hood. But before the blastopore of the latter is completely closed two smaller portions separate off from the hypoblast, and these are distinctly marked by the great abundance of granules they contain. They are of a *deep red colour*, and lie just within the blastopore. I do not hesitate to interpret these red cells as the rudiment of a *mesoblast*, from which the ovaries, the muscles, the excretory vessels, and the clavate organ (in the foot) originate.

The developing mesoblastic rudiment does not form a layer, but only a *cell-cord*, which grows from each side towards the anterior end of the body (between the epiblast and hypoblast). It is impossible to trace this growth in detail, because finally the larger hypoblastic cell begins to divide, and then the differentiation of the middle from the inner lamella becomes illusory. But by turning the egg upon its long axis we see that the mesoblastic cell-cord does not take a central course, but is more approximated to one half of the egg than to the other.

I do not think I am mistaken in regarding the first-mentioned red cells as those "primordial cells of the mesoderm," the occurrence of which in the development of the Annelida (in *Criodrilus*) was long since observed and described by Hatschek *.

Hatschek's fig. 1, pl. i. of the memoir cited, shows the cells in question exactly in the same position, with regard to the two primary lamellæ, in which I have met with them in the egg of *Philodina roseola*. In the latter object I could also ascertain beyond doubt *that the mesodermal rudiment takes its origin in the form of a portion cut off from the hypoblast.* When Hatschek says of these mesodermal cells "that they show a nearer relationship to the entoderm than to the ectoderm," it is correct and easily intelligible, as they stand in no genetic connexion with the latter.

By the evidence adduced by me the Rotatoria also show a significant relationship to the larva of *Polygordius* (the *trochophora*), of which we know that it possesses mesodermal streaks of exactly the same cellular constitution as the embryo of *Philodina roseola*.

Very probably the presence of a similar mesodermal rudiment would be ascertained also in *Rotifer vulgaris*, if we had any means of tracing the hypoblast in this animalcule more distinctly. It is, however, quite impossible in the case of *Rotifer* to ascertain anything about its further fate (after the ectoderm has grown over it). I obtained no result even by staining it (with methyl-green).

As regards the subsequent development of the embryos of *Rotifer vulgaris*, in the first place a cephalic and a caudal portion are constituted by a transverse furrow which early makes its appearance upon the ventral side. On the former the delicate outlines of the rotatory organ very soon appear in the form of two semicircular folds, which meet together in a middle line, the future œsophagus. At the same time we observe on the caudal (or pedal) portion some shallow emarginations by which the subsequent superficial segmentation of this section of the body is already expressed.

In the early developmental stages of *Rotifer* not the least trace of the internal organs is to be discovered; but their presence and their perceptibility certainly do not occur at the same moment. For no doubt the intestine is already present when the outlines of the pharynx and its denticulated jaw-plates begin to show themselves, which, as is well known, happens rather early. That at this period we are still unable to detect the digestive canal is probably due only to the fact that the difference between its refractive power and that of

* 'Studien über Entwicklungsgeschichte der Anneliden,' 1878, pp. 3 and 92 *et seqq.*

the surrounding tissue is considerably less than that which exists between the latter and the chitinous lining of the pharynx. It is therefore to the accidental existence of such a difference that we must ascribe the particularly early recognition of the pharynx in *Rotifer*.

Then there is in the posterior part of the embryo a small vacuole-like cavity, the early existence of which must be recognized. At the spot where this cavity is to be observed in embryos of *Rotifer* we see in young animals of *Lucinularia*, *Stephanoceros*, *Floscularia*, &c., small aggregations of granules (so-called "urinary concretions") which seem to be enclosed in a special vesicle. I am uncertain whether from the existence of these concretions the presence of a primordial kidney may be inferred, and only mention the interesting fact that Aubert also has observed in the embryo of *Aspidogaster conchicola* "two remarkable black points or spherules," of which he says that they strongly refract the light, have a stratified appearance, and constantly occur at the same spot (between the ventral sucker and the intestine) *. This is evidently perfectly analogous to the cases above referred to in connexion with the Rotatoria.

When the embryo of *Rotifer vulgaris* has advanced so far that it presents an exact likeness of its parent on a smaller scale, it begins to move briskly, and during this the uterine vesicle (*poche de maturation*) in which it is enclosed is in course of time ruptured. It is now quite free between the intestine and the body-wall, which space constitutes a sort of nursery for it after it has undergone the first act of its birth. We see such embryos, *i. e.* young Rotifers, creep about actively within the body of the parent, and frequently also the jaw-plates of the young animals are in clapping movement. In some cases I have seen such embryos with perfectly unfolded rotatory organs, making experimental vortices within the body-cavity of the parent. But this has occurred only two or three times during my investigations of many months.

I have already mentioned that I have never been able to see how the mature embryo escapes from the body of the mother, and is, so to speak, born for the second time. I doubt that the portal through which the young creature quits the narrow domain of its development is to be found in the cloacal aperture. The terminal intestine and the contractile vesicle alone open into this aperture. It must remain for other students of the Rotatoria to solve the mystery of the

* Zeitschr. f. wiss. Zool. vi. (1855), p. 370.

birth of these animals. I confess my complete ignorance upon this point.

V. *The Reproduction.*

On the 15th February, 1884, I found in one of my glasses some examples of *Rotifer* which showed eggs of the known size and form floating in the body-cavity, but besides these bore, attached to the inner surface of the cuticle, other egg-like structures, which seemed to derive their origin (by gemmation) from Leydig's "granular layer."

This was to me an extremely unexpected and startling sight. On closer examination the whole of the Rotifers in the glass in question proved to be furnished with such ova of the second kind. By selecting suitable examples it was possible to follow the progress of the process of budding with the greatest distinctness. Every drop of water that I placed upon an object-slide contained ten or twelve Rotifers. In these the budding-ova could be observed in all possible stages of maturation.

But were they really "ova" that here presented themselves to observation? This question naturally occurred to me, and I examined the literature that I had at my disposal in connexion with this point. But nowhere could I find any statement from which I could infer that before me any one had observed such budding-ova in *Rotifer*. Unexpectedly there came into my hands a note in the 'Archiv für Naturgeschichte' (1871, Bd. ii. p. 468), according to which Ganin had ascertained the formation of eggs by budding in *Callidina parasitica* (a Philodinid parasitic in *Gammarus pulex*). According to Ganin's report the egg-buds originate from the matrix of the cuticle, surround themselves immediately with a structureless membrane, become further developed, and then separate by constriction. But, together with these, true ova capable of development are also produced by the same wheel-animalcule.

This note agreed admirably with my own observations. I had seen the development of the buds from the granular layer (= matrix). I had accurately ascertained that these gradually grow into ellipsoidal structures, which, in external form, exactly agree with the ovarian ova of *Rotifer vulgaris*. However, the matrix-ova observed by me remained in connexion with their place of origin even after they had attained their definitive size. It was only in a few instances that I found them floating in the body-cavity like the ovarian eggs. Otherwise they always had their anterior extremity imbedded in the granular layer, and a small process even passed into the interior of the chitinous cuticle. Seen from the surface they appeared somewhat differently. I now ascertained that the cuticle immediately over the egg *was perforated*, and that the micropyliform opening thus produced appeared to be surrounded by a small annular wall (fig. 5) *.

I have seen such "eggs" attached from within both at the anterior and posterior ends of the body in my Rotifers. That any definite position was preferred for their attachment could not be perceived. Nevertheless it sometimes seemed as if the anterior part of the body-cavity (on the right) and the posterior part (on the left) more frequently bore "eggs" attached to them than other places. The appearance of the structures in question, when they have attained their definitive size, is shown by fig. 6. The whole forms an oval hyaline vesicle, at one pole of which there is a globular finely granular structure; while in the neighbourhood of the micropyloid aperture a vacuole-like cavity has been developed. I think I have observed that the vacuole can change its place within the vesicle; in many cases I have seen it in the immediate neighbourhood of the globular structure. The latter appeared to me to be capable of certain amœboid movements; I have seen it sometimes furnished with knobs and blunt diverticula, which, however, were retracted after a short time.

Up to this point I had made my observations under a power of only 550 diameters, but now it occurred to me to examine the vacuole, which, under this power, appeared quite light and clear, with a Leitz oil-immersion objective (of $\frac{1}{16}$-inch focus and a numerical aperture of 1·25). The employment of this objective gave a power of 900 diameters.

When I now glanced into the microscope my astonishment was great. The vacuole showed in its interior numerous swarming filaments, and, indeed, most of them were accumulated at the side where the wall of the vacuole touched the globular body (fig. 7). What were these filaments?

Since I became acquainted with Ganin's previous observation I had no other thought, *à priori*, but that I had before me true (although differently formed) eggs of *Rotifer*, and in

* On a careful examination of fig. 1 (*Stephanoceros Eichhornii*) on the first of the four plates which Prof. Leydig has appended to his fine memoir on the structure and systematic position of the Rotatoria, I see a structure, marked with the letter *h* (on the right at the fore part of the animal), of which the distinguished histologist confesses that its significance was unknown to him. He describes it as "a group of limpid vesicles which open on the cuticle by a duct, which, although short, is distinct in a suitable position." Have we not here a similar observation to that which I have frequently made in *Rotifer*?

accordance with this nothing was more natural than to regard the motile filaments in the interior of the vacuole as *spermatozoids*.

There was yet another circumstance that strengthened me in this conviction. Thus one day I observed that some of my examples of *Rotifer* were endowed with remarkable sac-like *appendages*, which were always situated exactly at the spot where the micropyloid aperture of the "egg" passed out through the cuticle. I observed these little sacs for hours, but could not at first arrive at any conclusion as to their nature. I only obtained an idea of how firmly they must adhere to the *Rotifer*, because they kept their position, as if firmly rooted, in spite of the rapid movements of the animals through whole masses of algal growth. After some time I happened to make a few preparations (merely in order to see whether the glass vessels still had living inhabitants), and then I succeeded in observing the following process in one of the saccules :—

In the apparently homogeneous contents of this a vacuole suddenly made its appearance (fig. 8, *a*), and moved downwards (towards the micropylar structure) pretty rapidly. The passage of the vacuole through the opening in the cuticle actually took place, and then immediately there appeared within the "egg" a small vesicle of the same kind, only rather smaller (fig. 8, *b*). A portion of the original vacuole remained behind in the neck of the micropylar orifice. Where the vacuole first appeared in the saccule a sharply contoured fissure made its appearance, which, however, soon showed dissolving margins, and finally disappeared altogether. Two minutes afterwards a new vacuole formed at the same spot as before; but this immediately broke up into two smaller ones (fig. 8, *c*), and both these again took their course towards the micropyle. This time *both* passed into the vesicle, so that now three such structures were present in it. Two of these, however, soon fused together, and then only two remained; but in about fifteen minutes these also united and caused the formation of a single larger cavity in the interior of the ovate vesicle.

All these remarkable processes I believed to be connected with a hitherto overlooked sexual mode of reproduction in *Rotifer vulgaris*, and this the more because the saccules vividly remind one of the spermatophores of many Crustacea (Cyclopidæ).

Prof. Ehlers (of Göttingen), however, called my attention to the fact, that years ago (1872) Prof. Friedrich von Stein (of Prague) described, before the meeting of naturalists at Leipzig, an Infusorial parasite belonging to the order Suctoria (and therefore allied to the Acinetina and Opalina), which my description of the egg-like structure in the body-cavity of *Rotifer vulgaris* suited most exactly. Prof. von Stein was now consulted with regard to the present case, and he had the kindness to compare my representation with his own previous observations. From this it became exceedingly probable that I had again met with the same parasite which Prof. von Stein had formerly discovered and described under the name of *Trypanococcus rotiferorum*.

Prof. von Stein, in the discourse which he delivered before the above-mentioned meeting of naturalists, made very detailed statements upon the organization of *Rotifer* and the structure of *Trypanococcus*, but unfortunately he did not prepare a report upon it for the 'Tageblatt.' This explains why *Trypanococcus* is not so well known as it certainly deserves to be.

What I regarded as a cavity (vacuole) filled with spermatozoids in the supposed "egg," is, according to Stein, the body-cavity of the parasite, which is lined with delicate, constantly vibrating cilia. From this body-cavity a canal (œsophagus) is supposed to go to the repeatedly-mentioned micropyloid aperture, which then would acquire the significance of a mouth. Upon this, however, I have to remark that I have *never* observed the presence of such an œsophagus even when employing the oil-immersion lens. If I had recognized any canal of the kind I should hardly have arrived at the notion that the structures in question were to be interpreted as "eggs." On the other hand, I must admit that a stomach with cilia on its inner wall very well explains the visual impression which I referred to a vacuole filled with swarming filaments. The globular structure in the vesicle of *Trypanococcus* is regarded by Stein as the nucleus of the Infusorial parasite.

The question now arises, however, as to what is represented by the *saccules*, the presence of which I have quite indubitably ascertained, and in which I was able to detect such peculiar phenomena of contraction with formation of vacuoles. Prof. von Stein declares that he never saw such sacciform appendages upon his Rotifers; but he is of opinion that they may very well be interpreted as a phenomenon of reproduction. Possibly a ciliated offshoot may be produced by gemmation, from which, finally, the motionless and parasitic *Trypanococcus*-vesicle proceeds. It is unfortunate that Prof. von Stein has no facts relating to the actual course of such a bud-formation, and that, in consequence, we can here proceed only upon hypothetical grounds. It was precisely these saccules, which appeared to me to be attached (connected) from without, that supported me in my notion of a sexual form of reproduction in *Rotifer*, although I should have been at a loss to indicate in this group of animals any organ which presumably might have the function of a male sexual gland.

The objections of Prof. von Stein to any other view than that in the present case we have to do only with *Trypanococcus*, are certainly of great weight. Nevertheless the matter is not yet fully elucidated, and it is of the greatest interest that all naturalists who occupy themselves seriously with the anatomy of the Rotatoria should look out for the presence of *Trypanococcus*, by which means we may by degrees obtain more accurate information as to the history of the reproduction of this remarkable Infusory.

For the elucidation of the question of egg-gemmation it would also of course be of great importance if Prof. Ganin would have the kindness to give further details of his observations, made in the year 1871, upon *Callidina parasitica.* He has no doubt already done this in no. 6 of the 'Transactions of the University of Warsaw,' but the memoir in question is written in Russian, and therefore not generally accessible.

With regard to the *reproduction* of *Rotifer vulgaris* I have therefore only been able once more to confirm the long-known fact that it takes place *parthenogenetically.* That besides the ovarian eggs, which are developed *without* previous fecundation, others are from time to time produced (by gemmation) which undergo fecundation, is rendered very doubtful by what Prof. von Stein has objected against my observations. Whether the previous observations of Prof. Ganin, which certainly seem to be in favour of a second kind of egg-formation in Philodinidæ, are really so well founded as to exclude all doubt, I am unable to judge. As already said, it is very desirable Prof. Ganin should speak out upon this point.

The subject under consideration is both biologically and physiologically of the greatest possible importance.

EXPLANATION OF PLATE V. B.

(A selection of figures from the author's plate. The original numbers are indicated in brackets.)

Fig. I [1]. An adult example of *Rotifer vulgaris*, seen from the ventral surface. *Auf*, eye-spots, shining through; *ro*, rotatory organ; *gs*, grey substance (salivary glands?); *z*, paired cells; *ka*, masticatory apparatus; *dr*, stomachal glands; *i*, inner membrane of the intestine; *eg*, excretory system of vessels; *zo*, tremulous organs (ciliated funnels); *ov*, ovary, with an ovum in course of constriction; *cbl*, contractile vesicle; *fdr*, pedal gland; *fe*, protrusible extremity of the foot.